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14. ABSTRACT
Under this program, we will develop algorithms to automatically classify images of the nighttime ionosphere and the structure that occurs therein. Doing so will allow for climatologies of the properties of these structures to be compiled. The climatologies will allow for a more complete understanding of when and where these irregularities occur and their effects on trans-ionospheric radio wave propagation.

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Specification of Nighttime Ionospheric Irregularities: Occurrence, Spatial, and Dynamic Properties

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LONG-TERM GOALS

Under this program, we will develop algorithms to automatically classify images of the nighttime ionosphere and the structure that occurs therein. Doing so will allow for climatologies of the properties of these structures to be compiled. The climatologies will allow for a more complete understanding of when and where these irregularities occur and their effects on trans-ionospheric radio wave propagation.

OBJECTIVES

The primary objective of this program is to develop algorithms to automatically classify images of the nighttime ionosphere and the structure that occurs therein. We will use these algorithms, as well as hand-verified classifications, to construct a climatology of these structures in the Pacific and S. American sectors using a multi-year database that has been compiled. From the classified images, we will study the spatio-dynamical properties of the structures in the images and how they relate to disturbances on trans-ionospheric radio wave propagation.

A secondary objective is conducting a ground campaign in New Mexico to study the linkage between lightning, gravity waves in the mesosphere, and the occurrence of mid-latitude structure in the ionosphere. This will provide valuable insights into the linkage of different atmospheric regions and the upward coupling of energy which is believed to have a significant impact on the ionosphere.

APPROACH

Imaging is the only observing modality that can easily provide high-resolution measurements of the spatio-dyamical properties of two-dimensional (latitude/longitude) ionospheric structures. Over the past seven years, we have amassed a large dataset of optical and collocated radio observations of ionospheric irregularities from several locations. We will develop automated analysis algorithms to extract pertinent spatio-temporal properties of ionospheric structures from the imaging database. Effects on trans-ionospheric radiowave propagation are studied using collocated radio (GPS) measurements. A database of structure occurrence, drift velocity, widths, and altitudes as a function of longitude, season, and solar cycle are being created and analyzed. The analysis routines are being developed such that they could be run in near real-time as part of an ionospheric structure specification network.

WORK COMPLETED

The following tasks have been completed:

(1) The algorithms developed in the pre-proposal phase have been revamped to off-load processing intensive operations onto a graphical processing unit (GPU), speeding up the classification schemes.

(2) A team of students has been assembled to begin classifying the entire dataset of images collected from sites in the Pacific and S. American sectors. This will serve as the truth data set to which the automatic classification scheme will be compared.

RESULTS

In the short time we have been working on this project, we have learned how to translate code written in Matlab, the language in which the original classification scheme was written, to the NVIDIA CUDA parallel computing architecture. Although only a small portion of the classification scheme has been translated at this time, we have found a marked increase in speed (a factor of 2) of the functions that have been translated.

IMPACT/APPLICATIONS

As described above, our goals are to develop an automated classification scheme that can run in real time for the detection of ionospheric irregularities using images of the nighttime ionosphere. This could be deployed to essentially provide a user with a “weather map” of regions of the sky in which it is expected that radio wave propagation will be adversely affected.

HONORS/AWARDS/PRIZES

Ronald W. Pratt Faculty Outstanding Teaching Award, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, 2009.